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Evaluation and Modelling of Emulsion Droplets Characteristics for stable Oil and Gas Wells Performance

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Abstract: *This study evaluates and model emulsion droplets characteristics for stable oil and gas wells performance. The focus of this work is on the eradication of liquid fall-back in an oil and gas wells and this is narrowed to the determination of the minimum diameter of emulsion droplet at the bottom of the well and the maximum emulsion droplet sizes for each of the dispersed phases, producing gas velocity and critical velocity that can lift the emulsion droplets from the reservoir to the surface. The minimum diameter of the emulsion droplet was gotten with the conditions that if gas flow provides enough energy to keep the emulsion droplets in suspension in the gas, gravitational force equals the sum of the resistance force and the buoyant force inasmuch as the emulsion is spherical in shape and smooth. The minimum diameter of the emulsion droplet at the bottom was*124µm*. The values of the maximum stable emulsion droplet sizes from the bottom to the surface were 825µm, 498µm, 496µm, 494µm and 488µm, 484 µm, 481 µm, and 480 µm respectively. The producing gas velocities to lift the emulsion droplets from the bottom to the wellhead were 5.27m/s, 5.24m/s, 5.28m/s, 5.33m/s, 5.33 m/s, 5.35 m/s, 5.37 m/s and 5.39m/s respectively. The critical velocity at the wellhead to be the controlling factor for liquid loading, which was 0.230m/s. Whenever the critical gas velocity is greater than the producing gas velocity, liquid fall-back occurs. In conclusion, liquid loading is eradicated as the producing gas velocities are greater than the critical velocities that can lift the liquids from the bottom to the surface. It was recommended among others that the engineering simulation software (HYSYS) should be used for controlling emulsions droplets characteristics of oil and gas wells with a view of determining stable conditions for achieving a better performance.*

Keywords: Emulsion droplets, oil and gas wells

INTRODUCTION

Gas producing wells are experiencing persistent production decline during their lifetime. The decreasing gas production is subject to the nature of reservoir depletion. However, a greater than expected production decline often follows the already justified reservoir pressure depletion, especially when multiphase mixture in the wellbore has relatively high liquid to gas ratio that exceeds permissible water content limit in the well (Höök et al., 2014). Gas production profile deviates from stable to unstable indicated by erratic and oscillating behaviors of surface measurements of pressure and flow rate. Emulsion droplet is induced by dynamic interaction between multiphase flow in the reservoir and multiphase flow in the wellbore. The production impairment situation is also not sustainable and may ultimately lead to the end life of the well if appropriate prevention or remediation actions are not delivered in timely manner (Lim et al., 2015).

Emulsion droplet is the dispersion of one water in another immiscible liquid. Examples of emulsion droplets include crude oil and water which can form an oil-in-water emulsion, and multiple emulsions. Crude oil and gas are multifaceted raw materials due to their applications in more diverse range of sectors than other energy sources and they constitute the cleanest burning fossil fuel (Berdzenadze, 2015).

According to Clifford (2015), the exact origin of this petroleum reservoir is not cleared but is considered to be from plants, animals and marine life through thermal and bacterial breakdown. The composition of crude oil mainly comprises of organic compounds, principally hydrocarbons with inorganic non hydrocarbon compounds (small percentages), such as carbon dioxide, sulphur, nitrogen and metal compounds. Some natural gas is released as associated petroleum gas along with the oil. A well that is designed to produce only gas may be termed a gas well. Wells are created by drilling down into an oil or gas reserve that is then mounted with an extraction device such as a pump-jack which allows extraction from the reserve. Creating the wells can be an expensive process, costing at least hundreds of thousands of dollars, and costing much more when in hard to reach areas, i.e. when creating offshore oil platforms. The process of modern drilling for wells first started in the 19th century, but was made more efficient with advances to oil drilling rigs during the 20th century (Groom, 2020).

Wells are frequently sold or exchanged between different oil and gas companies as an asset – in large part because during falls in price of oil and gas, a well may be unproductive, but if prices rise, even low production wells may be economically valuable. Moreover new methods, such as hydraulic fracturing (a process of injecting gas or liquid to force more oil or natural gas production) have made some wells viable. However, peak oil and climate policy to fossil fuels has made fewer and fewer of these wells and expensive techniques viable. Izuwa et al (2015) carried out a review on evaluating the effects of flow conditions on liquid loading in a gas well of a maturing gas field. In his study, operation conditions such as tubing Head flowing pressure, water gas ratio and condensate gas ratio were used to study the impact of operating conditions on liquid loading in gas wells. The study found out that at reduced THP, gas flow rate increases. This increased rate might cause erosion of tubing and facilities in the well. At a lower flow rate liquid will not flow to the surface. This condition makes it necessary to have an optimum producing conditions. The sensitivity analysis showed an optimum rate of

120MMscf/d to unload liquid and also flow rates lower than the Turner rate will cause liquid loading. The well will therefore be managed between the Turner rate and the erosional velocity rate.

In the gas production industry, gas transportation to the downstream customers plays a major role in determining the economic viability of the operations. Emulsion droplets can pose considerable flow assurance problems and greatly affect the capacity of separators, pumps and pipelines. For example, Boukadi et al (2012) calculated separator sizing using modified Arnold-Stewart's method and claimed that the retention time is increased from base case of 3-20 min to 8-53 min, when emulsion droplet viscosity is taken into consideration. Longer retention time would be translated as larger separator size and larger footprint area to accommodate the separator. Besides that, higher concentration of emulsions is also correlated to larger value of pressure drop and as the water-in-oil emulsion droplets concentration is increased towards the inversion point, the pressure drop can be up to 8 times higher than the pressure drop of pure oil (Lim et al., 2015). Emulsions droplets can be classified on the basis of the properties of the dispersed phase and the dispersion medium as Oil in water (O/W), Water in oil (w/o) and multiple emulsion droplets (Dima 2019).

This study was based on Turner's model. Turner et al (1969) pioneered work in analyzing and predicting the minimum gas flow rate that can still prevent liquid loading. They presented two mathematical models describing the liquid loading problem: the film movement model and the entrained droplet movement model. Turner et al (1969) were of the opinion that since water film accumulation on the walls of a conduit during two-phase gas/liquid flow is inevitable due to the impingement of entrained water drops and the condensation of vapours. They also suggested that the annular liquid film must keep moving upwards along the conduit walls to keep a gas well from loading up, and in the same vain the minimum gas flow rate necessary to accomplish this is of primary importance in the prediction of liquid loading. The analysis technique used involves describing the profile of the velocity of a water film moving upward on the inside of a tube. The major shortcoming of this model was its inability to clearly define between the adequate and inadequate rates when it was analyzed with field data.

The existence of water drops in the gas stream presents a different problem in fluid mechanics, namely, that of determining the minimum rate of gas flow that will lift the drops out of the well (Turner et al.,1969). In a bid to do this, Turner et al. proposed a model to calculate the minimum gas flow velocity necessary to remove water drops from a gas well which is based on the sole principle of a freely falling particle in a fluid medium. Turner et al.'s entrained drop movement model was derived from the terminal settling velocity of liquid droplets and the maximum droplet diameter corresponding to the critical Weber number of 30. Turner et al.'s terminal slip velocity equation is expressed in the equation below:

$$V_{SL} = \frac{1.3\sigma^{1/4}(\rho_L - \rho_G)^{1/4}}{C_D{}^{1/4}\rho_G{}^{1/2}} \qquad \text{Equation 1}$$

Where, σ= Interfacial tension; $\rho_L - \rho_G$ = Densities of liquid and gas, kg/m^3; C_D = Drag coefficient; V_{SL} = terminal slip velocity, m/s.

The aim of drilling an oil well is to produce either oil or gas from the reservoir through tubings to the surface. Sometimes this process is faced with challenges one of which is the formation of complex and extremely stable emulsion droplets which may serve as a barrier during the production process of crude oil or gas. The barriers caused by emulsion droplets in production may be reservoir depletion and liquid loading. Other effects of emulsions are: erosion formation, contamination of products, degradation of equipment and oil well abandonment.

Some gas wells in oil and gas industries are abandoned after the completion stage even when much money and man power has been sunk into it. Over the years, government and oil producing companies have been abandoning wells due to one problem or the other from one location to the other even at the point of production. Less attention has been paid to what causes well abandonment. It is basically on this ground that this research seeks to analyze oil emulsions as it contributes to liquid loading, erosion formation, equipment degradation, products contamination and oil wells abandonment. It is expected that the outcome of this work will be beneficial to the researcher and other individuals such as the government and oil producing companies. It will spur up awareness for future investigations. The problem of oil wells abandonment, equipment degradation and liquid fallback or liquid loading will be eradicated from the well bore as emulsion droplets will be carried to the surface. Development of an efficient mechanistic based simulation model which accounts for all relevant parameters affecting emulsion in oil well is of great economic and safety interest because it will reduce liquid loading and production cost although oil and gas exploration/production is complex but a lucrative business to oil companies. Hence, this study was based on evaluation of the impact of emulsion droplets in an oil and gas industry production line.

Aim and Objectives of the Study

The aim of this study was to evaluate and model Emulsion droplets characteristics for stable oil and gas wells performance. The objectives were:

i. To determine the minimum diameter and maximum stable emulsion droplet sizes for the dispersed phases (water- in-oil and oil-in-water).
ii. To determine the producing gas velocity that can carry the emulsion droplets from the reservoir to the surface or surface.
iii. To determine the critical velocity that can carry the emulsion droplets from the reservoir to the surface or surface.

MATERIALS AND METHODS

The materials involve a typical molar data of petroleum reservoir fluid (Guo et al., 2007) and an oil well data with known temperature, pressure, molar flow rates, internal and external diameters of tubing, depth of well and standard length of pipe. Another most important material in use for this work is engineering simulation software developed by Aspen Technologies Incorporated, called HYSYS (OneLiner V15.6: 2022).

Data Collection Procedure

Operational and process data used by ExxonMobil for offshore applications at different oil fields located in Eket, Akwa Ibom State from 2017 to 2020 were sampled in this analysis as shown in Table 1 below. The method started by getting a letter of introduction from my Head of department to ExxonMobil in Akwa Ibom State, thereafter, the required mixed fluid data was given to me as shown in Table 1.

Table 1: Operational Gas Well Data for Eket (2017-2020)

Temperature	Molar Flow Rate of gas	Molar Flow Rate of water	Pressure	Pipe Length	Pipe Diameter	True vertical depth
85^0C	15.2kg/s	0.36 kg/s	25000KN/m^2	500m	$4.0''(0.1016m)$ External Diameter $3.52''(0.0894m)$ Internal Diameter	3500m

Data Analysis

The following steps were taken to analyze the fluid data.

i. First, the procedure started by clicking on the start menu and selecting HYSYS among the various programs in the computer system.

ii. Secondly, hydrocarbons were added with respect to Table 1 as 'new case' was opened from the file menu.

iii. Thirdly, the component list was specified and the fluid composition was put into the program, and then normalizes to give a total mole fraction of one.

iv. Fourthly, Peng-Robinson equation of state was selected from 'add command' as the fluid package was opened. The Peng-Robinson fluid package is the preferred fluid package for hydrocarbon mixtures. It is recommended for oil, gas and petrochemicals because it calculates with a high degree of accuracy the properties of single-phase, two-phase and multi-phase systems.

v. Fifthly, stream 1 for gas and stream 2 for water were added as "flow sheet" was selected from the simulation environment. Stream 1 contains the mole fraction of all the hydrocarbons.

vi. Sixthly, the fluid data (temperature, pressure, mass flow rate and so on) were added from Table 1 under "conditions".

vii. Lastly, a thermodynamic model called Beggs and Brill (1991) was chosen as the multiphase flow model and the simulation was entered. Depending on the depth of the well, the properties of saturated fluid at every 500m length of the pipe were obtained using HYSYS**.** The depth of the well was 3500m with seven different pipe segments of 500m each. At various depths of the well, HYSYS generated more fluid values for calculations as being summarized in Table 2 below. The temperature and other fluid properties vary depending on the depth of the well.

Table 2: Summary of some Fluid Properties at various depths of the well

Parameters	3500m deep	3000m deep	2500m deep	2000m deep
z	0.7891	0.7893	0.7897	0.7899
μ_G	7.781x10^{-5} Ns/m^2	2.17x 10^{-5} Ns/m^2	1.95x 10^{-5} Ns/m^2	1.82 x10^{-5} Ns/m^2
σ	0.041N/m	0.0077N/m	0.00695N/m	0.00693N/m
ρ_L	864.8kg/m^3	745.5kg/m^3	674.8kg/m^3	674.1kg/m^3
ρ_G	439.1kg/m^3	138.2kg/m^3	123.3kg/m^3	121.1kg/m^3
P	25000kPa	20000kPa	19180kPa	19010kPa
T	75.05˚C	70.01˚C	68.01˚C	65.03˚C
D	0.0894m	0.0894m	0.0894m	0.0894m
q_G	0.0331 m^3/s	0.0329 m^3/s	0.0332m^3/s	0.0335 m^3/s
Parameters	1500m deep	1000m deep	500m deep	Surface level
Z	0.7908	0.7910	0.7913	0.717
μ_G	1.801x 10^{-5}Ns/m^2	1.771x10^{-5} Ns/m^2	1.75x10^{-5} Ns/m^2	1.684x10-^{5} Ns/m^2
σ	0.006834N/m	0.00681N/m	0.00678N/m	0.00672N/m
ρ_L	673.5kg/m^3	672.1kg/m^3	563.7kg/m^3	542.2kg/m^3
ρ_G	120.9kg/m^3	120.5kg/m^3	120kg/m^3	119kg/m^3
P	18900kPa	18510kPa	18010kPa	17510kPa
T	63.12˚C	60.11˚C	59.04˚C	59.01˚C
D	0.0894m	0.0894m	0.0894m	0.0894m
q_G	0.0335m^3/s	0.0336m^3/s	0.0337m^3/s	0.0339m^3/s

Emulsion Droplets Diameter Modeling

Emulsion droplets diameter is the minimum size of emulsion droplets obtained at the bottom of the well. The smaller the diameter of the emulsion droplets at the bottom, the smoother and faster the rate of water flow from the reservoir to the surface. In evaluating emulsion droplets, the following conditions must be met; Emulsion droplets is spherical in shape of a regular cross section area; emulsion droplet surface is smooth; the forces exerted on liquid emulsion are gravity, drag force and buoyant force. Inasmuch as particles are considered spherical, the analysis is suitable to any particle of one phase dispersed in another. Sequel to these conditions, terminal velocity is attained, if gas flow provides enough energy to hold the emulsion in suspension in the gas. At this point, the force of gravity will be equal to the sum of the drag force and the buoyant force, and as such the emulsion droplets will travel at a steady rate and velocity. Hence, it can be represented as:

$$D_E = \sqrt[5]{\frac{12C_D\rho_G Q_{E^2}}{g\pi^2(\rho_L-\rho_G)}} \qquad \text{Equation 2}$$

Where, D_E = Minimum diameter or size of the emulsion droplet; C_d = Drag coefficient; ρ_G = density of gas (kg/m^3); ρ_L = density of liquid (kg/m^3); $Q_E = E$mulsion droplet flow rate (m^3/s).

While then maximum emulsion droplet diameter is:

$$D_{Emax} = \frac{25g\sigma}{\rho_G u_G{}^2} \qquad (N_{we} = 25 \text{ "Assummed"}) \qquad \text{Equation 3}$$

Where ρ_G = Density of gas, kg/m^3; U_G = Gas velocity, m/s; g = Acceleration due to gravity, m/s^2 and N_{we} = Weber Number.

Also, the gas velocity is given by:

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$U_G = \frac{q_G}{A}$ Equation 4

Where, u_G is the velocity of gas, m/s, q_G is the gas volumetric flow rate, m^3/s, and A is the cross-sectional area of pipe, m^2.

$A = \frac{\pi Di^2}{4}$ Equation 5

Where, A is the cross-sectional area of pipe, m^2, and D_i = internal pipe diameter (m),
D = 0.0894m (Table 1) and π = 3.142.
The critical velocity of the gas can be obtained as:

$u_c = 1.92\left[\frac{\sigma(\rho_L - \rho_G)}{\rho_G^2}\right]^{1/4}$ Equation 6

Where; u_c = critical velocity; σ = Interfacial tension, N/m; ρ_L = Density of liquid, kg/m^3 and ρ_G = Density of gas, kg/m^3

RESULTS

Minimum diameter and maximum stable emulsion droplet sizes for the dispersed phases

In equation 2 (Minimum diameter of emulsion droplet), substituting the values of ρ_G, ρ_L, π, g, C_D and Q. Therefore substituting the values of ρ_L and ρ_G from Table 1, and π = 3.142, C_D =0.2, g = 9.81 m^3/s and $Q_E = 0.0338\ m/s$, into equation 2; the minimum diameter of the emulsion droplets at 3500m length of pipe becomes; $D_E = 0.124x\ 10^{-3}m$**.** This is the minimum size of the emulsion droplet at the bottom. The smaller the emulsion droplet size, the smoother the flow will be from the bottom to the surface.
The maximum stable emulsion droplet sizes for each dispersed phase was gotten from equation 3. At 3500m deep: where, ρ_G = 439.1kg/m^3; u_G= 5.27m/s; σ = 0.041N/m and $g = 9.81$ m/s^2.

$D_{Emax} = 0.000825m$

At 3000m deep: ρ_G = 138.2kg/m^3; u_G= 5.24m/s; σ = 0.0077N/m and $g = 9.81$ m/s^2, $D_{Emax}0.000498m$
At 2500m deep: where, ρ_G = 123.3kg/m^3; u_G= 5.28m/s and σ = 0.00695N/m, $D_{Emax} = 0.000496m$
At 2000m deep: where, ρ_G = 121.1kg/m^3; u_G= 5.33m/s and σ = 0.00693N/m, $D_{Emax} = 0.000494m$
At 1500m deep: where, ρ_G = 120.9kg/m^3; u_G= 5.33m/s and σ = 0.006834N/m. $D_{Emax} = 0.000488m$
At 1000m deep: where, ρ_G = 120.5kg/m^3; u_G= 5.35m/s and σ = 0.00681N/m, $D_{Emax} = 0.000484m$
At 500m deep: where, ρ_G = 120kg/m^3; u_G= 5.37m/s and σ = 0.00678N/m, $D_{Emax} = 0.000481m$
At the surface level: where, ρ_G = 119kg/m^3; u_G= 5.39m/s and σ = 0.00672N/m, $D_{Emax} = 0.000480m$

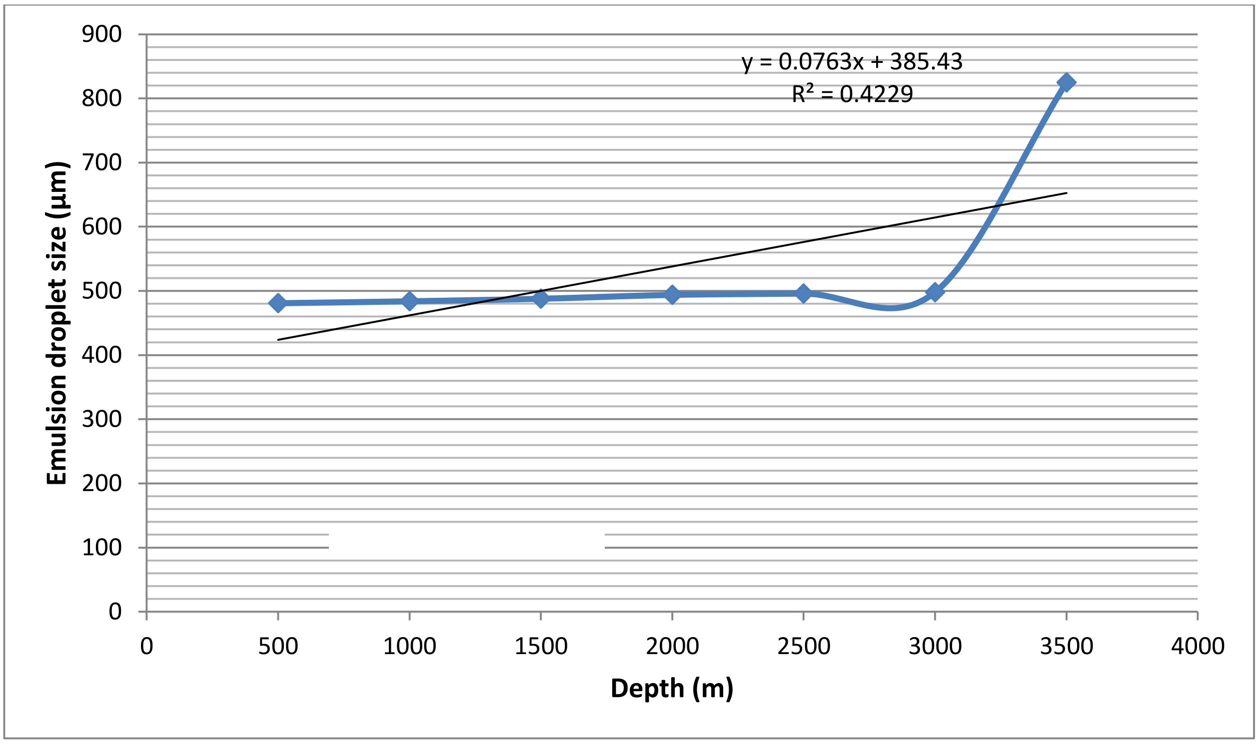

Fig 1: Graph of Emulsion Droplet Sizes (µm) against Depths (m)

Fig 1 shows the emulsion droplet sizes at various depths of the well. From the bottom of the well, the emulsion droplets size decreasing with decreasing depth till it reaches the surface. The emulsion sizes breaks in gas stream as they are carried along to the surface. The emulsion droplet size was high at the bottom of the hole and it becomes smaller as it passes via different sections of the pipe and landed the surface at 480 (µm).

Producing gas velocity that can carry the emulsion droplets from the reservoir to the surface

From equation 5 above, $A = 0.00628m^2$

From equation 4, the values of q_G from Table 2 were substituted, and the gas velocities at various depths of the well were obtained as;

At 3500m deep, $u_G = 5.27m/s$, At 3000m deep, $u_G = 5.24$m/s 500 1000 1500 2000 2500 3000 350

At 2500m deep, $u_G =$; 5.28m/s, At 2000m deep, $u_G = 5.33$m/s

At 1500m deep, u_G =5.33 m/s, At 1000m deep, u_G =5.35 m/s

At 500m deep, $u_G = 5.37$ m/s, At the surface level, $u_G = 5.39$ m/s

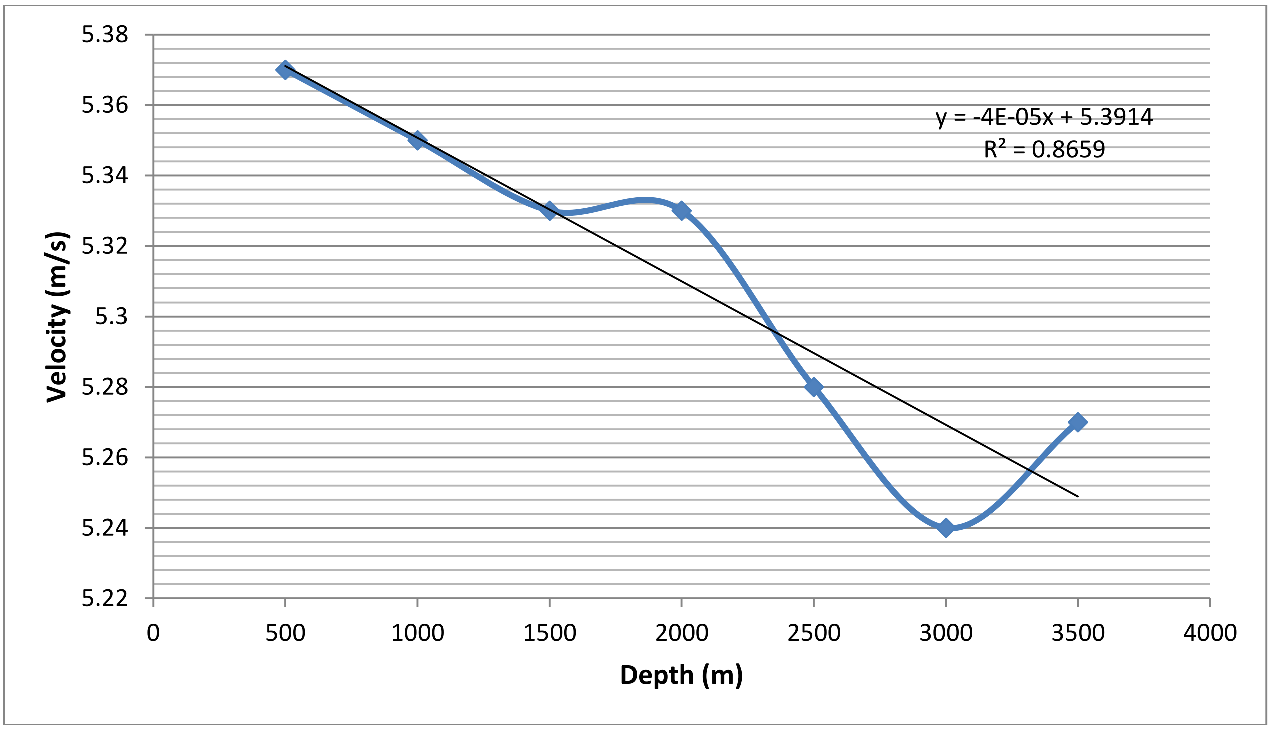

Fig 2: Graph of gas velocity (m/s) against well depth (m)

Fig 2 depicts that the velocity varies at different depths depending on the flow rates at different points. From the bottom of the well, the fluid velocity increases to the surface, but was stable between 1500m to 2000m deep. The maximum velocity was at the surface (5.39m/s).

Critical velocity that can carry the emulsion from the reservoir to the surface

From equation 6 and in Table 2, substituting the values of σ, ρ_G and ρ_L

At 3500m deep: U_C=0.187m/s, At 3000m deep: U_C= 0.241m/s

At 2500m deep: U_C=0.242m/s, At 2000m deep: U_C= 0.226m/s

At 1500m deep: U_C=0.265m/s, At 1000m deep: U_C = 0.245m/s

At 500m deep: U_C=0.231m/s, At the surface level: U_C= 0.230m/s

Therefore, the critical velocity at the wellhead is taken to be the controlling factor for liquid loading, which is 0.230m/s. The critical velocity at the bottom of the well was 0.187 m/s and was smaller than that of the surface (0.230m/s).

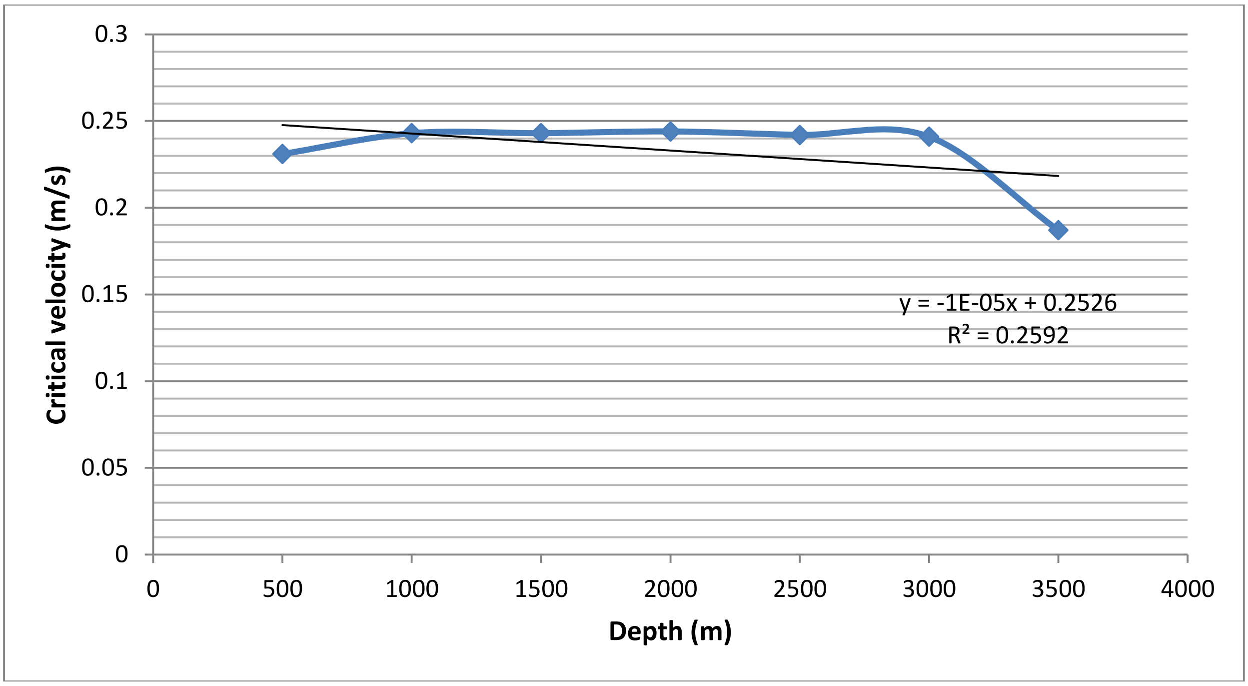

Fig 3: Graph of Critical velocity (m/s) against depth (m)

Fig 3 shows the graph of critical velocity with depth. The graph shows that the critical velocity varies depending on the well formations.

Critical velocity helps to predict the point of liquid loading in the well. In this thesis, it was predicted at the wellhead. The critical velocity was found at the surface to be 0.230 m/s which was the controlling factor for liquid loading. The critical velocity at the bottom of the well was smaller than that of the Christmas tree. The critical velocity at the bottom was 0.187 m/s.

DISCUSSION

The results of the analysis showed that the minimum diameter of the emulsion droplets at the bottom was smaller than the internal diameter of pipe gotten from Eket oil well and it was recorded as 124 µm. Turner et al (1969) model which is best recommended for oil and gas production wells was used due to its accuracy, simplicity and precision and the values of the maximum stable emulsion droplet sizes from the bottom to the surface were 825µm, 498µm, 496µm, 494µm,488µm, 484µm, 481µm and 480µm respectively. The producing gas velocities to lift the emulsion droplets from the bottom to the wellhead were 5.27m/s, 5.24m/s, 5.28m/s, 5.33m/s, 5.33 m/s, 5.35 m/s, 5.37 m/s and 5.39m/s respectively. Turner et al (1969) recommends the critical velocity at the well head to be the controlling factor for liquid loading, which was 0.230m/s. Whenever the critical gas velocity is greater than the producing gas velocity, liquid loading occurs. These findings agree with that of Boukadi et al (2012) as they reported that decreasing gas production in oil and gas industry is subject to the nature of reservoir depletion as gas producing wells are experiencing persistent production decline during their lifetime. In the same vein, these findings are in line with that of Lim et al (2015) because they found that gas production profile deviated from stable to unstable indicated by erratic and oscillating behaviours of surface measurements of pressure and flow rate. The production impairment situation is also not sustainable and may ultimately lead to the end life of the well if appropriate prevention or remediation actions are not delivered in timely manner. Similarly, the findings collaborates with that of Izuwaet al (2015) as they found out that at reduced temperature and high pressure, gas flow rate increases. This increased rate might cause erosion of tubing and facilities in the well. At a lower flow rate, liquid will not flow to the surface. This condition makes it necessary to have an optimum producing conditions. The sensitivity analysis showed an optimum rate of 120MMscf/d to unload liquid and also flow rates lower than the Turner rate will cause liquid loading. The well will therefore be managed between the Turner rate and the erosional velocity rate. Emulsion droplets cause most of the drill wells to be abandoned due to the fact that there is no critical velocity to pull the liquids to the surface. This imposes back pressure into the system leading to liquid loading which is the main effect of emulsion droplets characteristics for stable oil and gas wells performance. The inability for the emulsion droplets to be lifted to the wellhead may be due to insufficient pressure, minimum gas velocity, critical velocity and rates to lift the liquids to the surface and so on. The factors affecting the size and distribution of emulsion droplets in oil and gas well risers include temperature, density, pressure, depth, compressibility factor, surface tension in the riser, volumetric flow rates, viscosity, cross sectional area of the tubing and pipe diameters. Liquid loading was eradicated as the producing gas velocities were greater than the critical velocities at various depths of the well and a better well performance was achieved.

CONCLUSION

Emulsion droplets does not occur on its own unless being triggered by an external force. When the water content in the reservoir is high, the producing gas velocity will not be enough to lift the co-produced water to the wellhead. The minimum diameter of the emulsion droplet at the bottom was gotten when the three forces acting on liquid emulsion droplet (gravitational force, drag force and buoyant force) were in equilibrium. The three forces acting on water emulsion droplets must be at balance for liquid loading to be eradicated from the well-bore; likewise the producing gas velocity should be greater than the critical velocity and rates that can lift the fluids to the wellhead.

Recommendations

This study evaluates and model emulsion droplets characteristics of oil and gas wells with a view of determining stable conditions for achieving a better performance. It is recommended from this analysis that;

1. The engineering simulation software (HYSYS) should be used for controlling liquid emulsion droplets in oil and gas well because of its high rate of liquid accumulation prediction, accuracy and reliability which ensures safety and brings about eradication of liquid fall-back.
2. The use of models by the Nigerian producing companies that will lead to decline in production rate and whose predictions are less than the actual emulsion droplets flow rate of oil and gas flow should not be encouraged nor practiced.
3. It is also recommended that the oil and gas regulatory body that is in charge of inspection should regularly ensure compliance with the use of high precision models and software for analyzing the critical velocity and rates so as to eradicate liquid loading for better well performance.

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